The Vertical Distribution of Aerosols and Their Optical Properties in GEOS during CAMP2Ex

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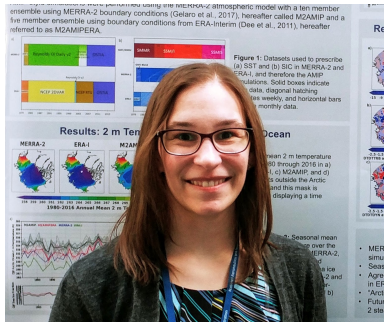
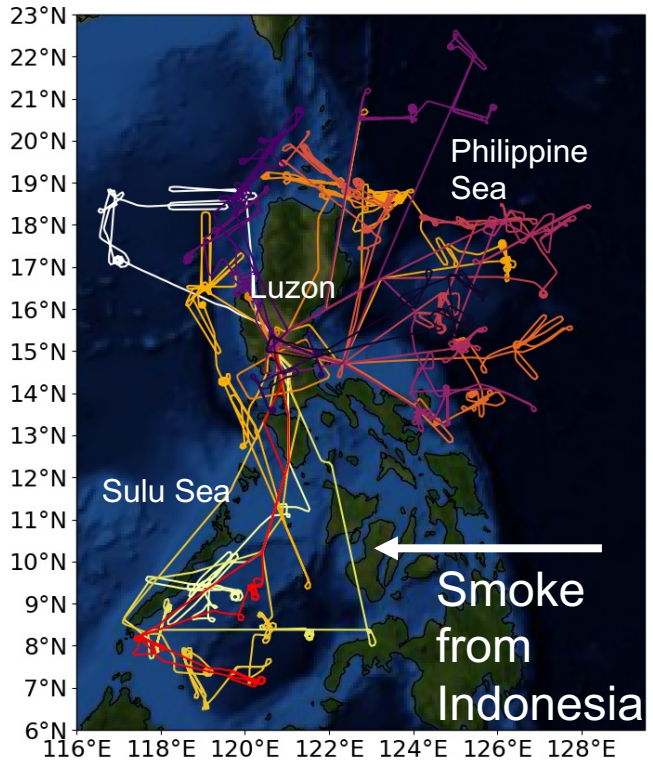


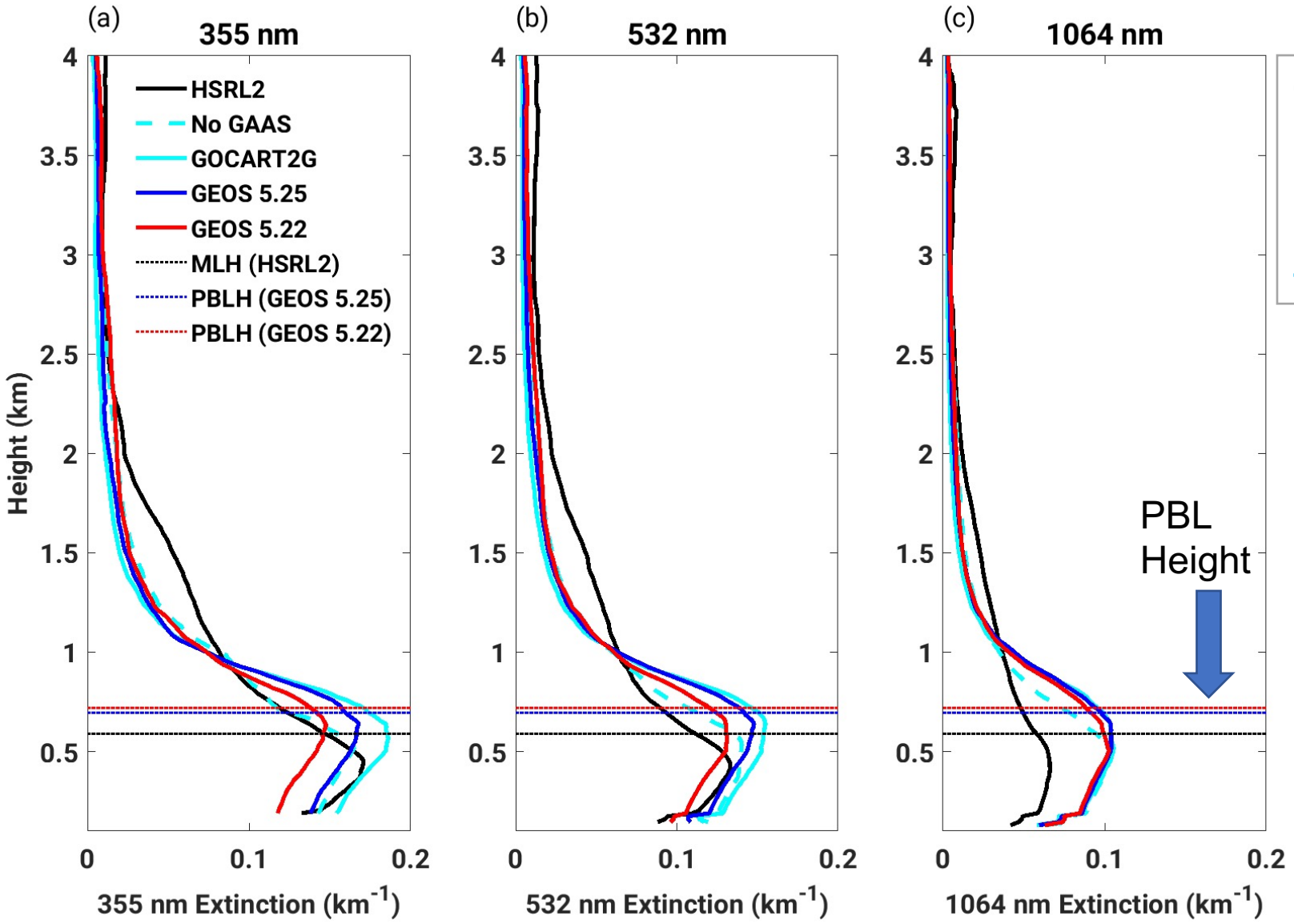
Introduction

- NASA P3 collected observations in the Philippines region before, during, and after the southwest monsoon transition
- Goal: Utilize observations from CAMP²Ex to evaluate and improve the representation of biomass burning aerosol in GEOS



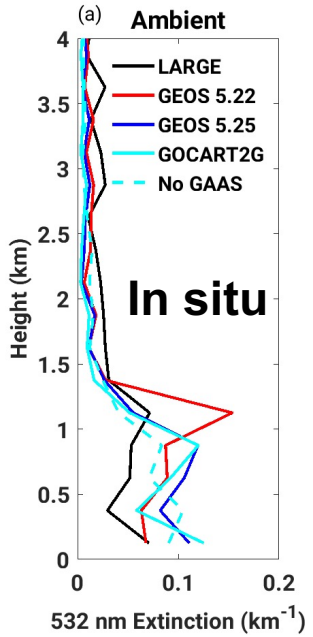
Observations	GEOS
LARGE =Langley Aerosol Research Group Experiment, aerosol mass and optics (Luke Ziemba)	Modular earth system model from NASA's GMAO
HSRL2 = High Spectral Resolution Lidar (Chris Hostetler)	GOCART Aerosol Module
FIMS = Fast Integrated Mobility Spectrometer, particle size distribution (Jian Wang)	Assimilation of conventional and satellite observations + MODIS aerosol optical depth

Campaign-wide Profile of Aerosol Extinction

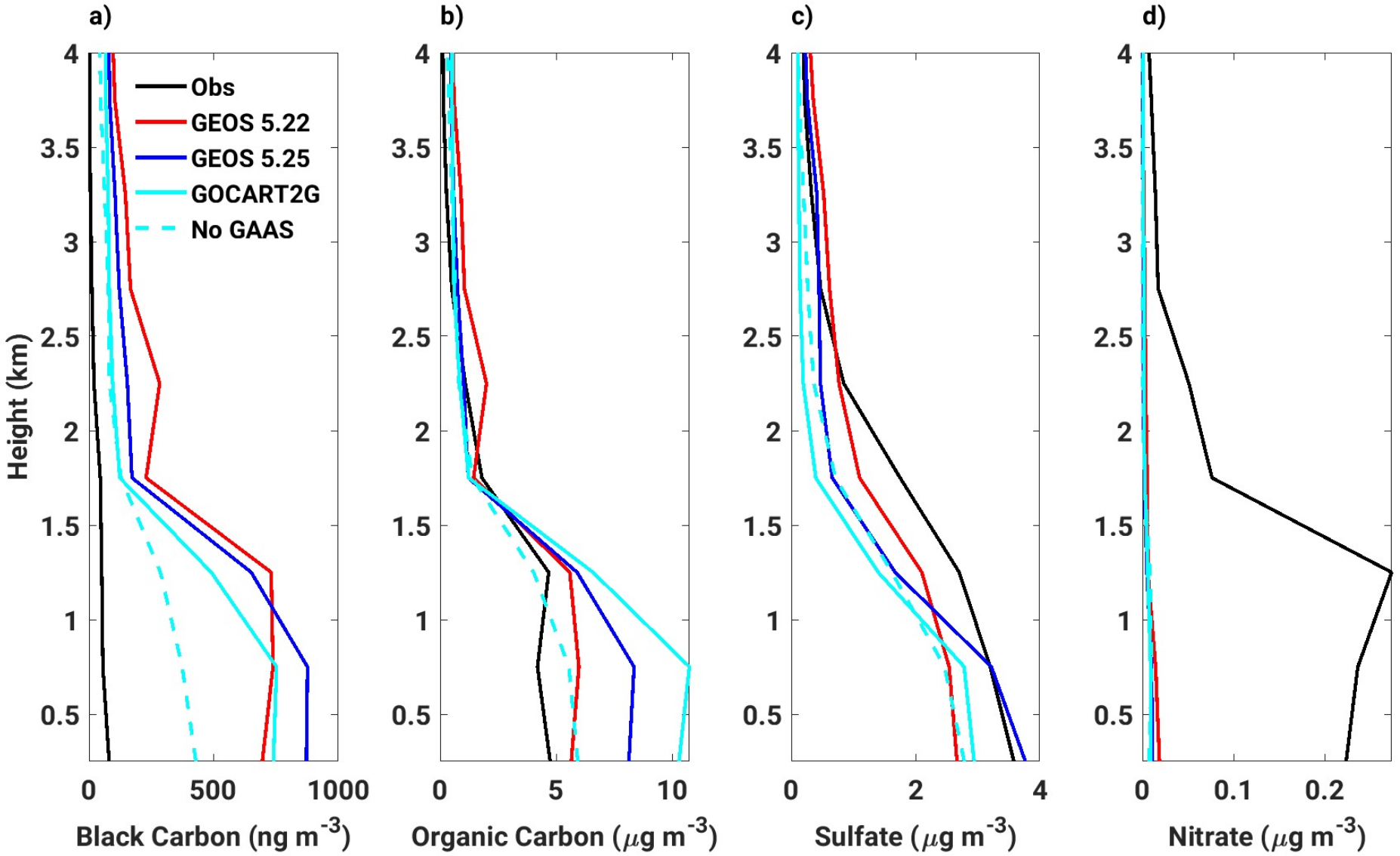


Observations (HSRL2, remotely sensed)
Baseline Model
+ Meteorology Updates (GF + shallow)
+ Meteorology and Aerosol Updates
--- No observational constraint for AOD

- PBL too deep in GEOS
- Too much extinction at the top of the PBL, not enough just above
- Magnitude of extinction bias is wavelength dependent
- Inadequate transport into the lower free troposphere?



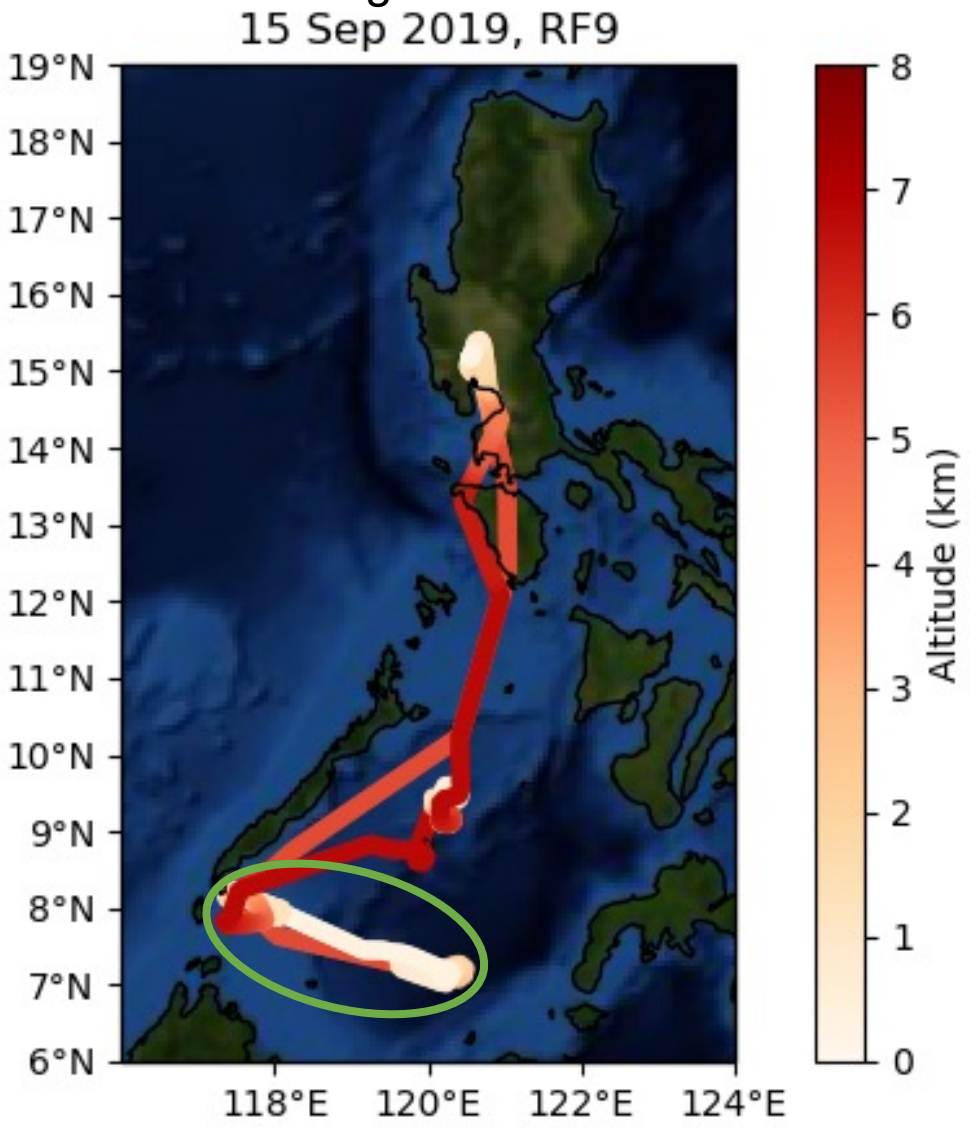
In-situ Aerosol Mixing Ratio Profiles

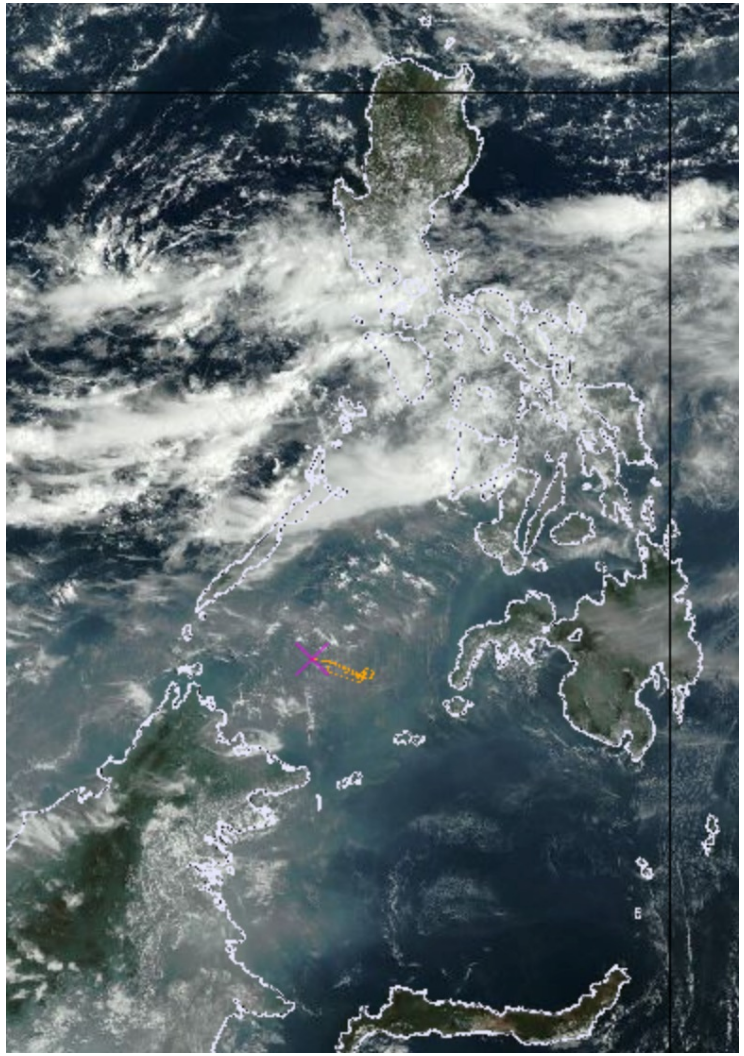


- Comparison to FLAMBE indicates biomass burning emissions are too low (GEOS missing peat fires), yet GEOS has too much carbon in BL
- Latest emissions from CEDS
  - Accurate?
  - Deficient production of sulfate and nitrate aerosol?
- Data assimilation for AOD adds aerosol mass, primarily as carbon despite the need for sulfate and nitrate
- Total aerosol mass in “No GAAS” is accurate

A Closer Look with a Single Transect through Aged Smoke

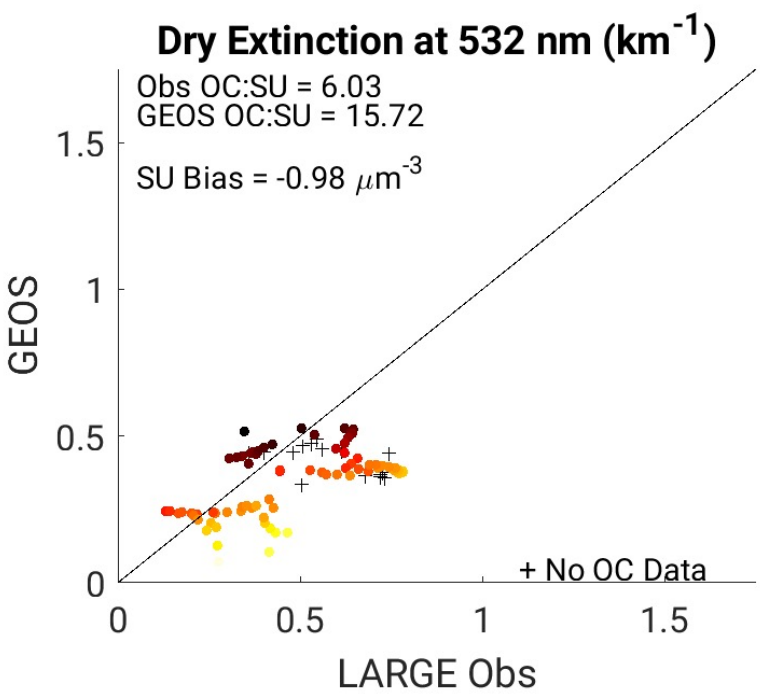
- Segment chosen due to consistent altitude, ideal for nephelometer

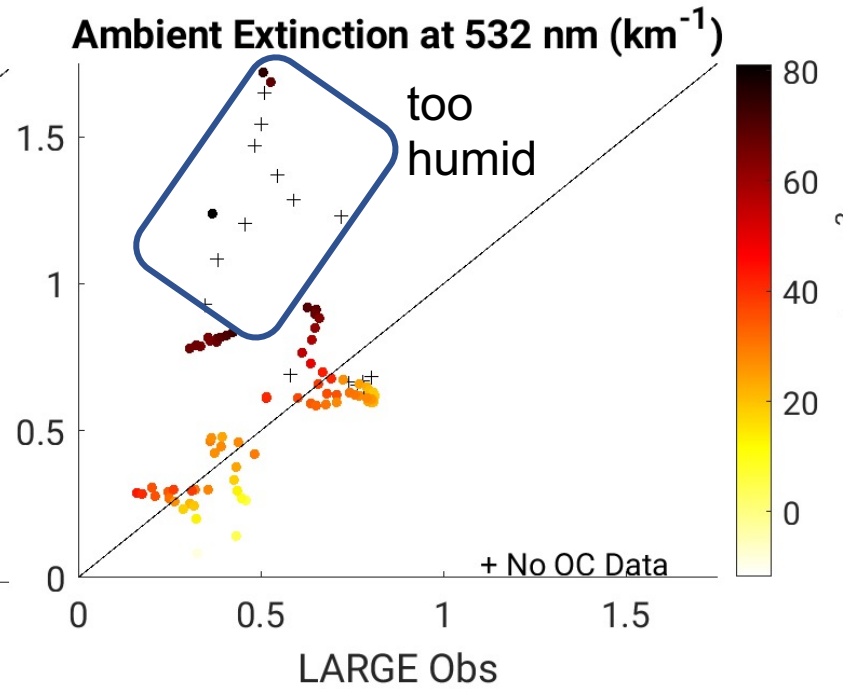


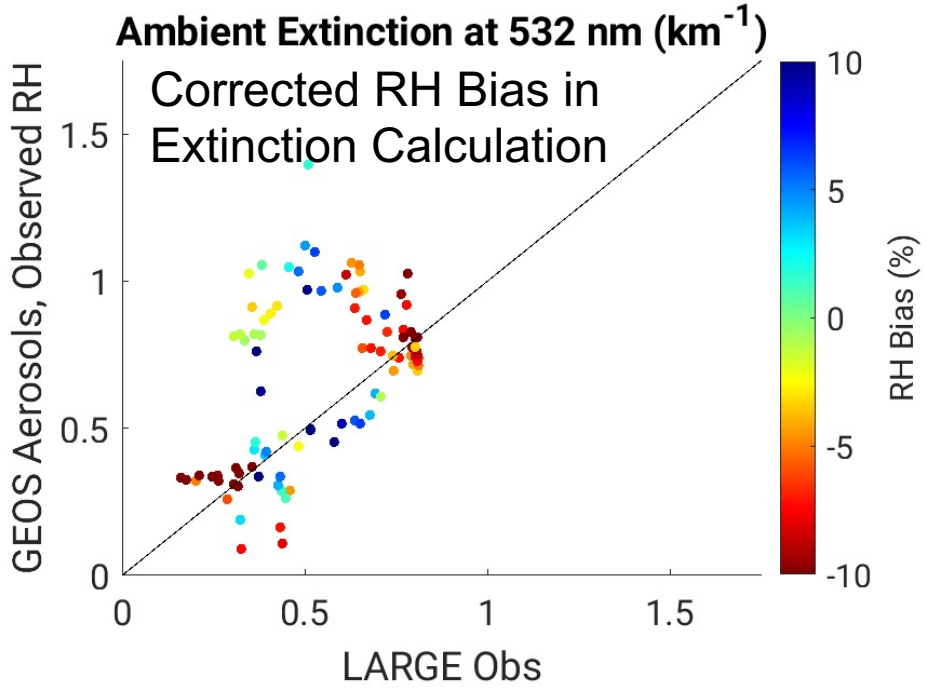


~1z 16 Sep 2019

Contribution of Humidity to 532 nm Extinction





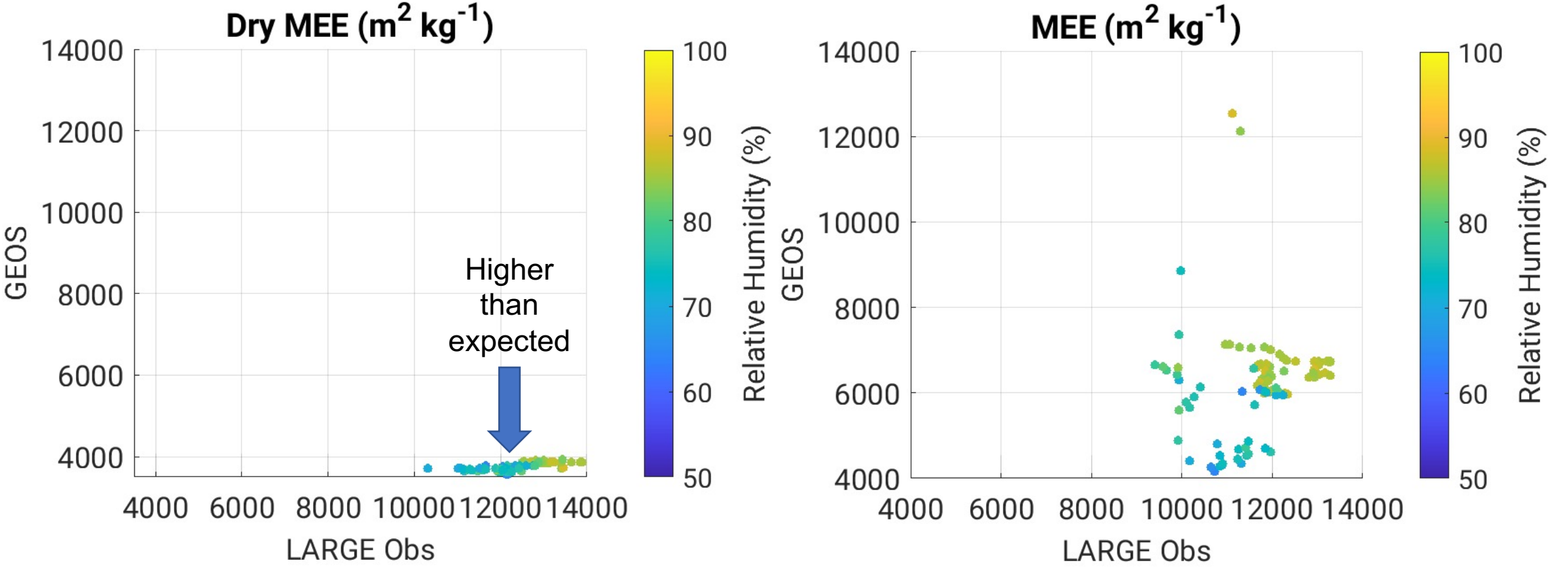


- AOD assimilation results in a positive bias in carbon mass
- Still slightly not enough extinction at 40% RH

- Excessive carbon + humidity = too much extinction
- PBL height too high in the model

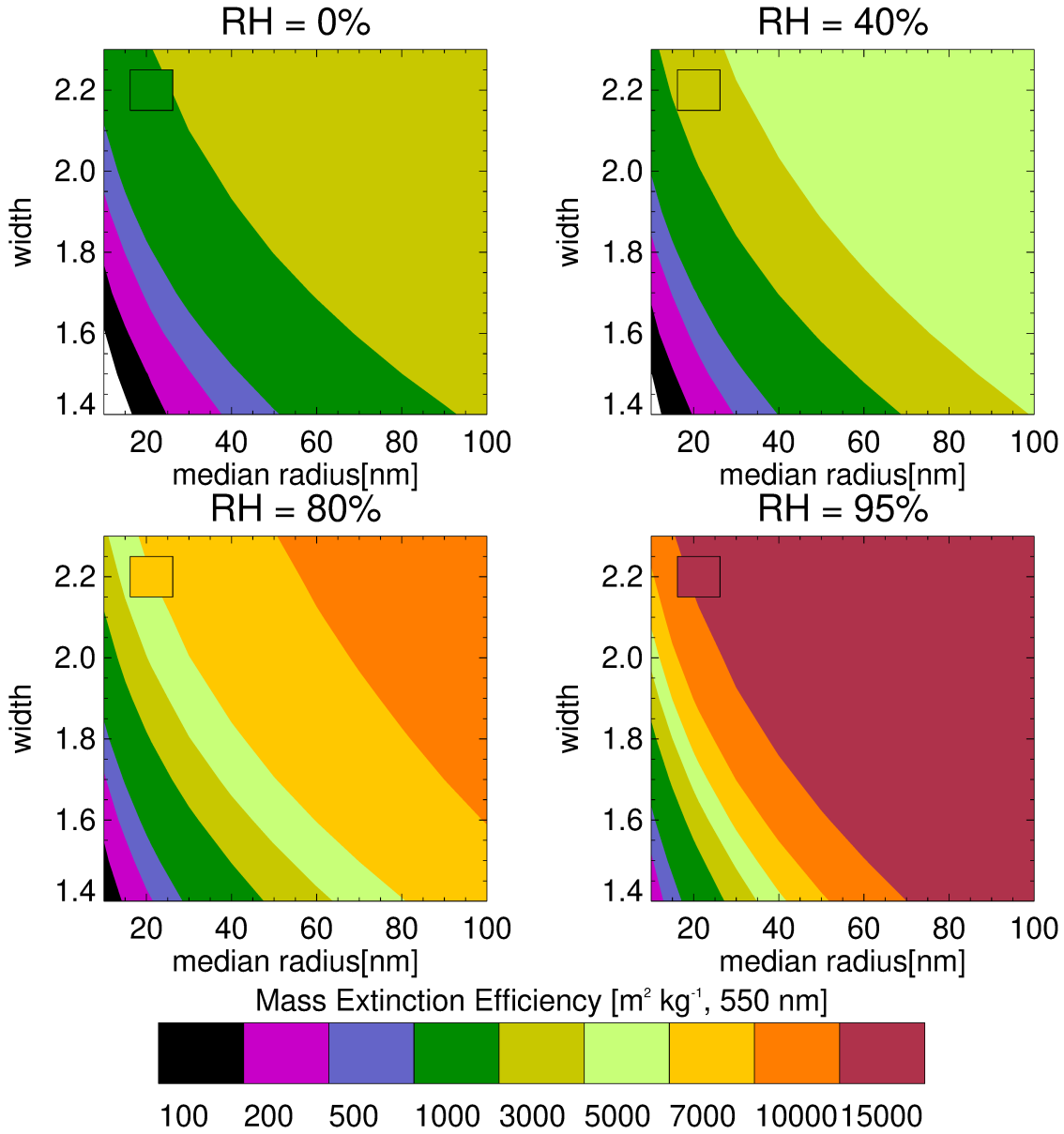
- Still too much extinction
- Some data points are worse

Mass Extinction Efficiency (MEE)



- MEE = amount of radiation absorbed or scattered per unit of aerosol mass
- Dry MEE greatly underestimated by GEOS
- Odd behavior when comparing dry to ambient MEE -> MEE decreases from dry to ambient conditions
- Observed f(RH) below 1, considered unphysical by the model (avg obs = 0.915, avg GEOS = 2.16)
- GEOS considers hydroscopic growth however carbon is divided between hydrophobic and hydrophilic

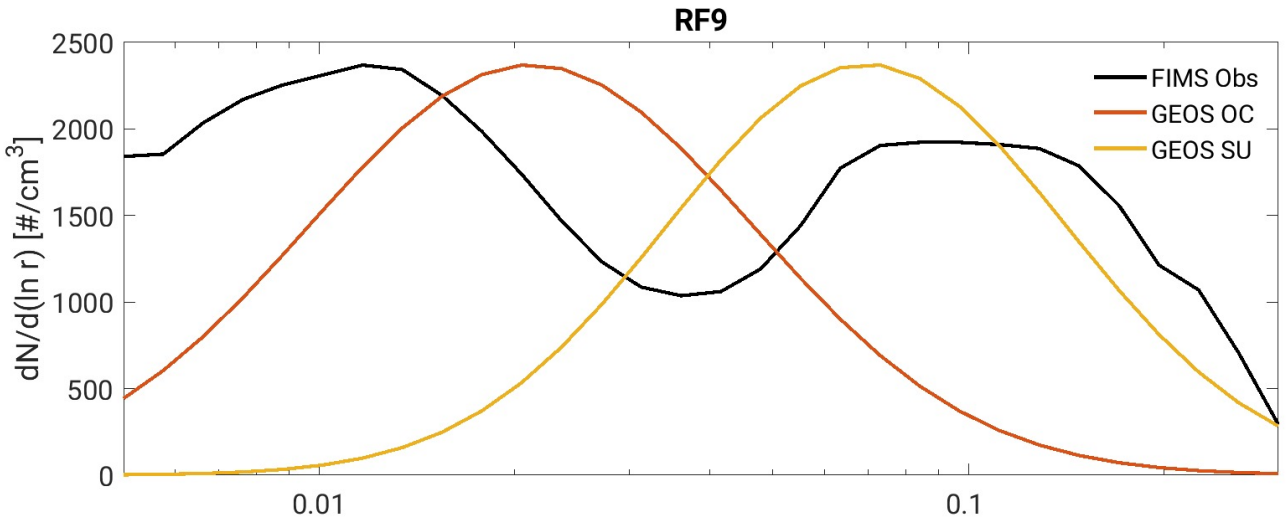
Modeled MEE is a function of RH and PSD

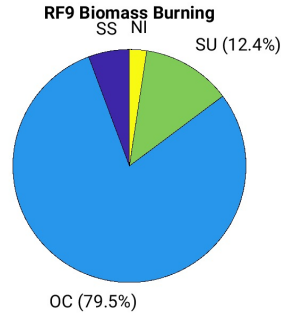


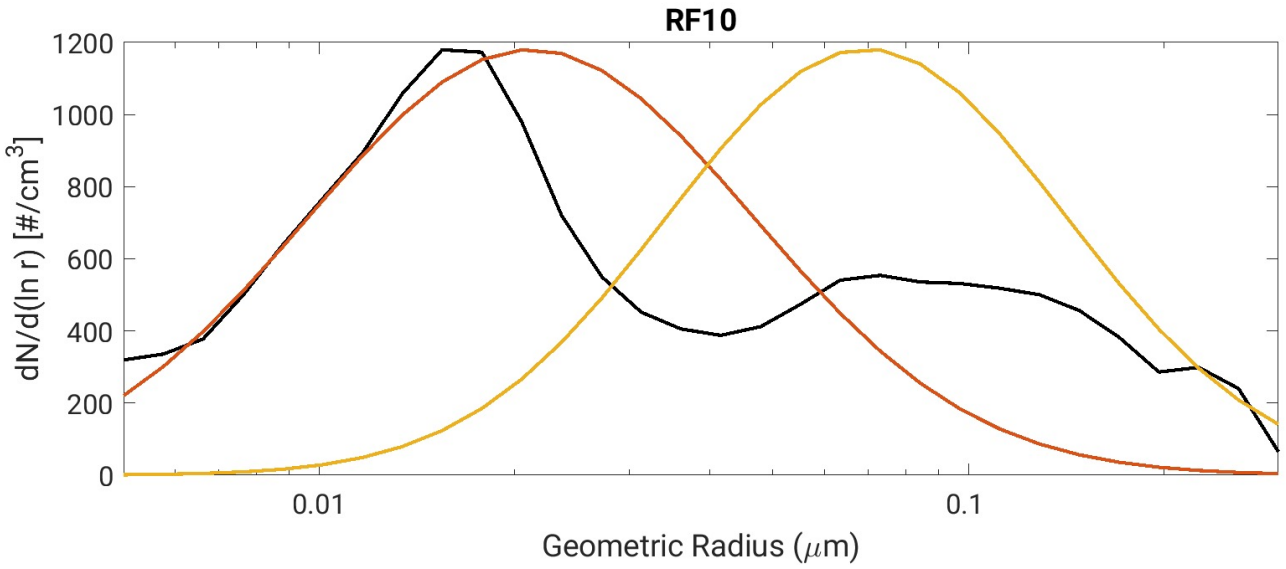
- Visualization of the optics table for brown/organic carbon

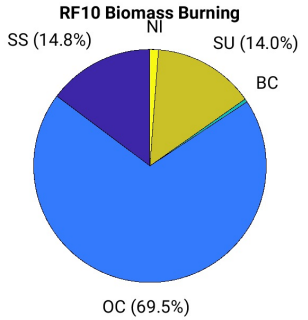
- Inset boxes indicate current assumptions used by GEOS for the particle size distribution
- These values are in line with what was shown GEOS
- However,…the observed dry mass extinction efficiency is not on the table!
- Observed ambient MEE suggests we should widen the width of the size distribution or increase the size of the median radius

Particle Size Distribution of Biomass Burning Aerosol



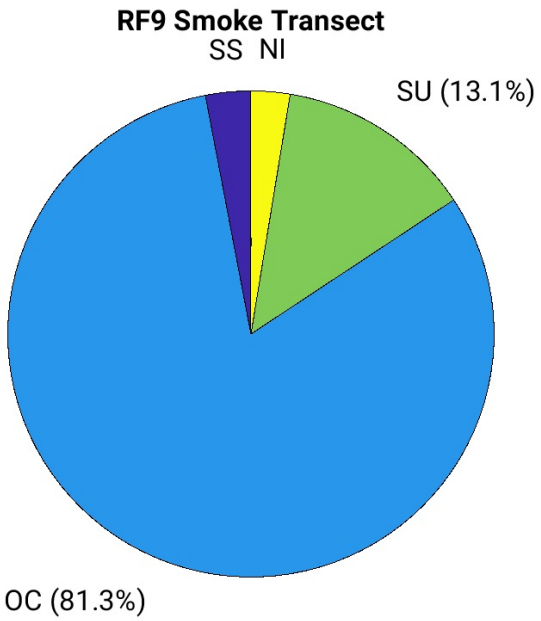


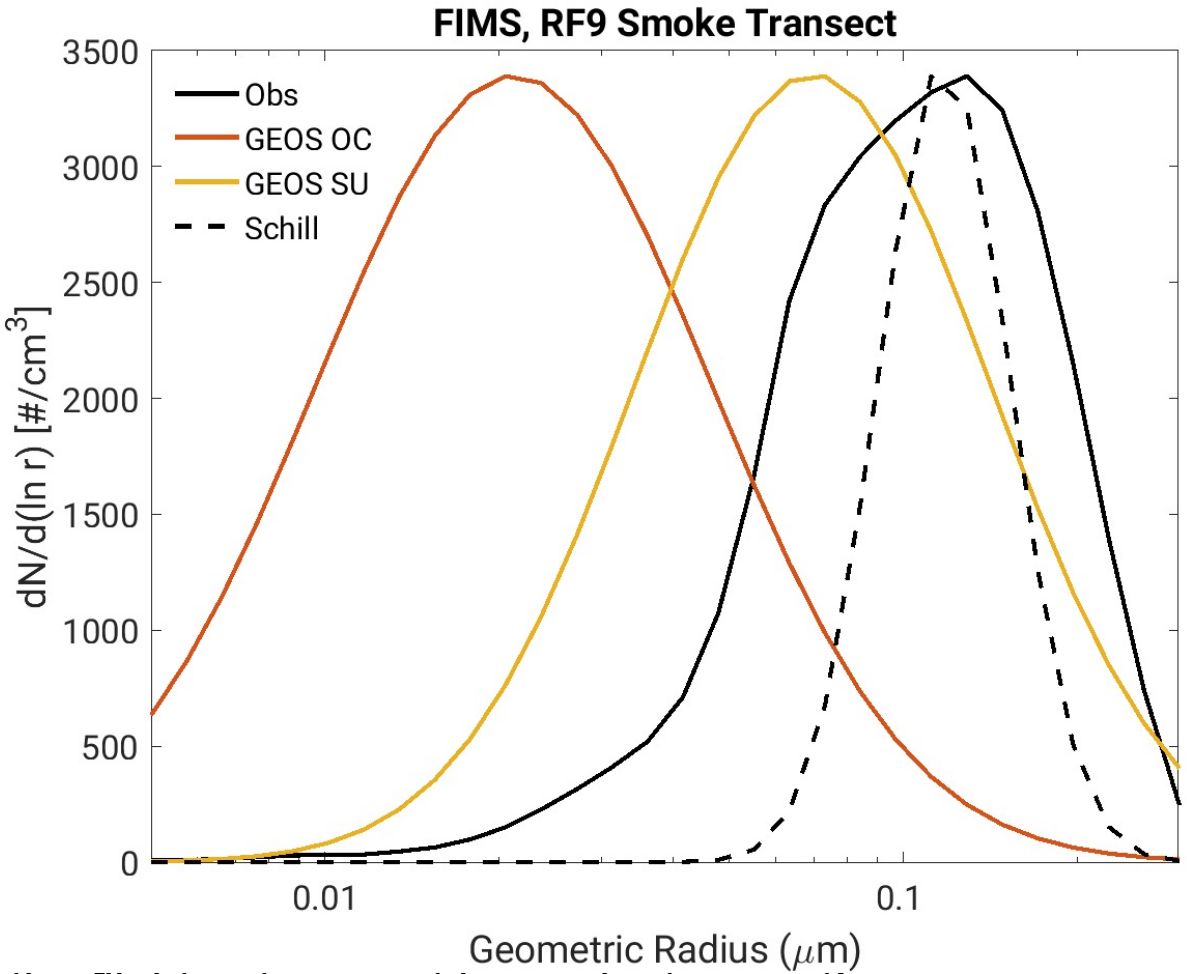




- Entire flights, filtered using biomass burning flag from Josh DiGangi
- Sample is dry
- GEOS PSD scaled to match max peak of FIMS observations
- Both flights dominated by Organics
- More sulfate and sea salt during RF10, ->rightward shift in primary peak
- Both flights have secondary peaks not represented in GEOS
- Overall agreement is poor

Particle Size Distribution from the RF9 Smoke Transect





- Primary peak from entire flight not present in smoke transect!
- Schill = proposed update to the size distribution based on PALMS observations from SEAC^{4}RS
- Schill distribution agrees much better with CAMP^{2}Ex mode radius, but suggests a narrower distribution

Conclusions

- Comparisons between CAMP^{2}Ex observations and GEOS suggest the MEE for carbon is too low in GEOS
- Results in excessive amounts of carbon added through the data assimilation process for AOD at 550 nm
- Additional concerns in hygroscopic growth, particle size distribution, and single scattering albedo (not shown)
- Consistent with other field campaigns, particularly ORACLES

Recommendations Moving Forward

- Rectify the unphysical nature of observed f(RH) and how to represent that in a model
- Reconsider how GEOS handles aging of smoke, carbon bleaching
- Represent the secondary peak in the observed PSD through brown carbon in GEOS (right now identical to organic carbon), however preliminary results suggest a degradation in SSA

Still to investigate

- Contribution of sulfate to the MEE in GEOS using other flight segments

Thank You!

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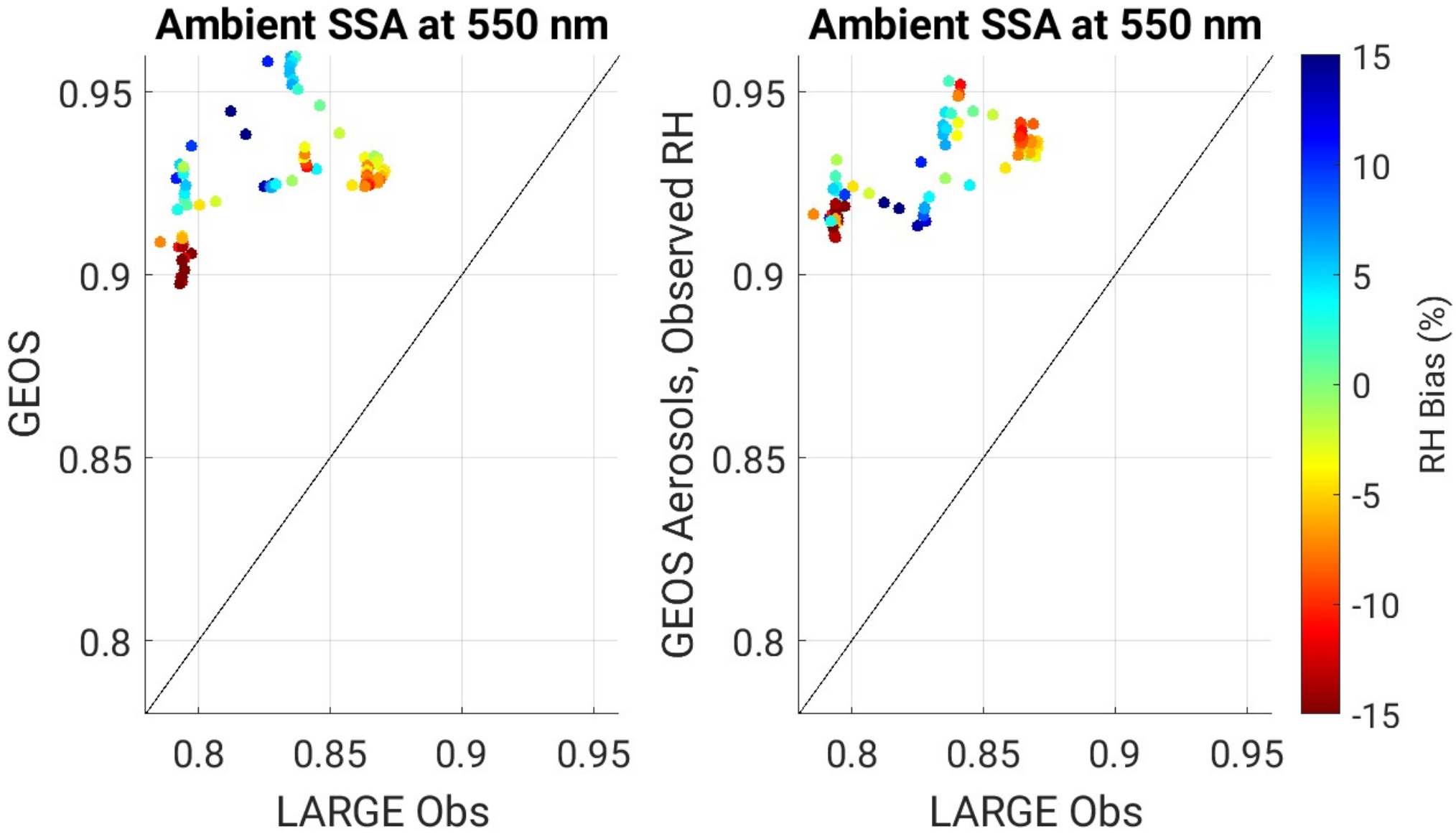
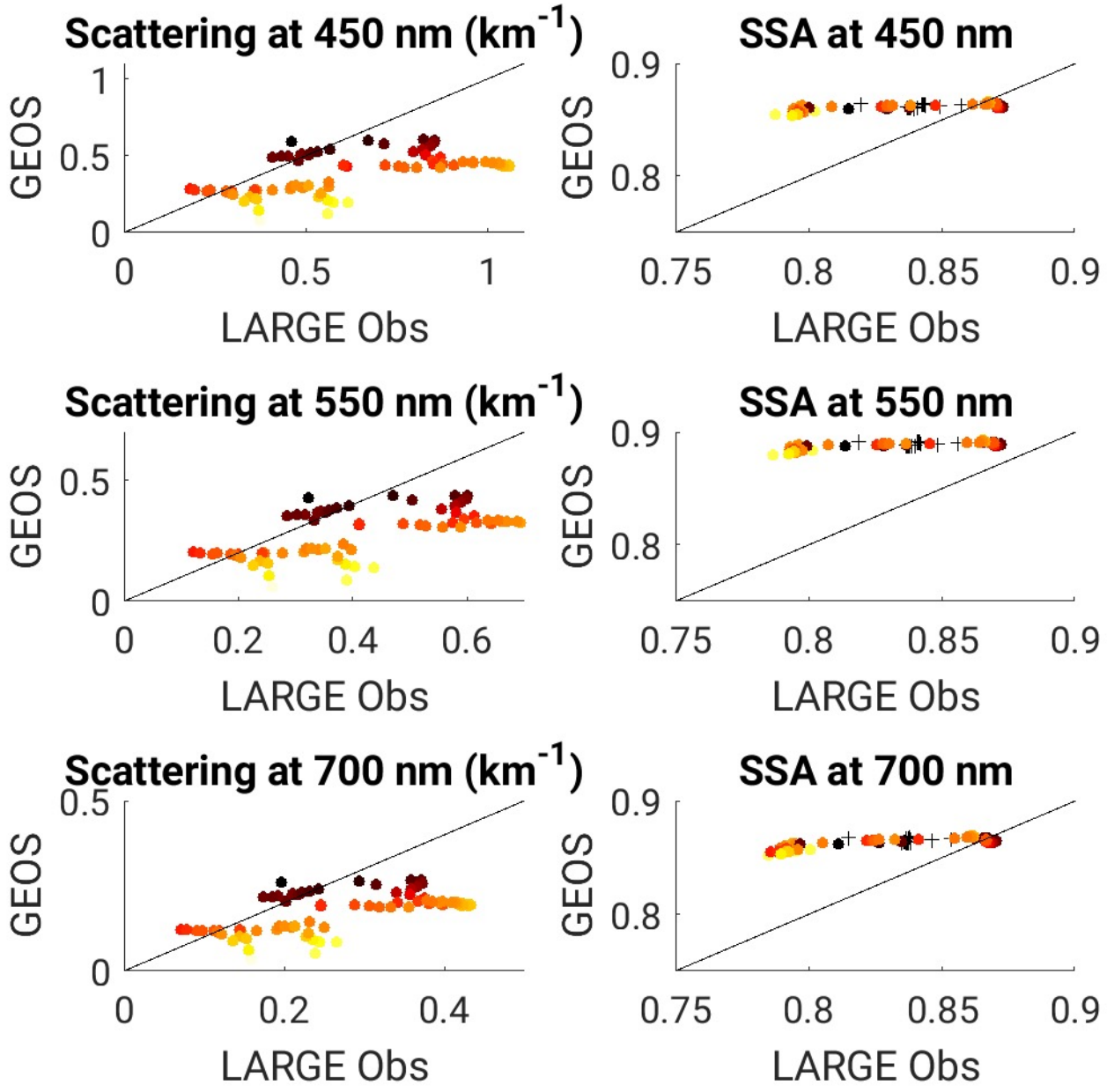
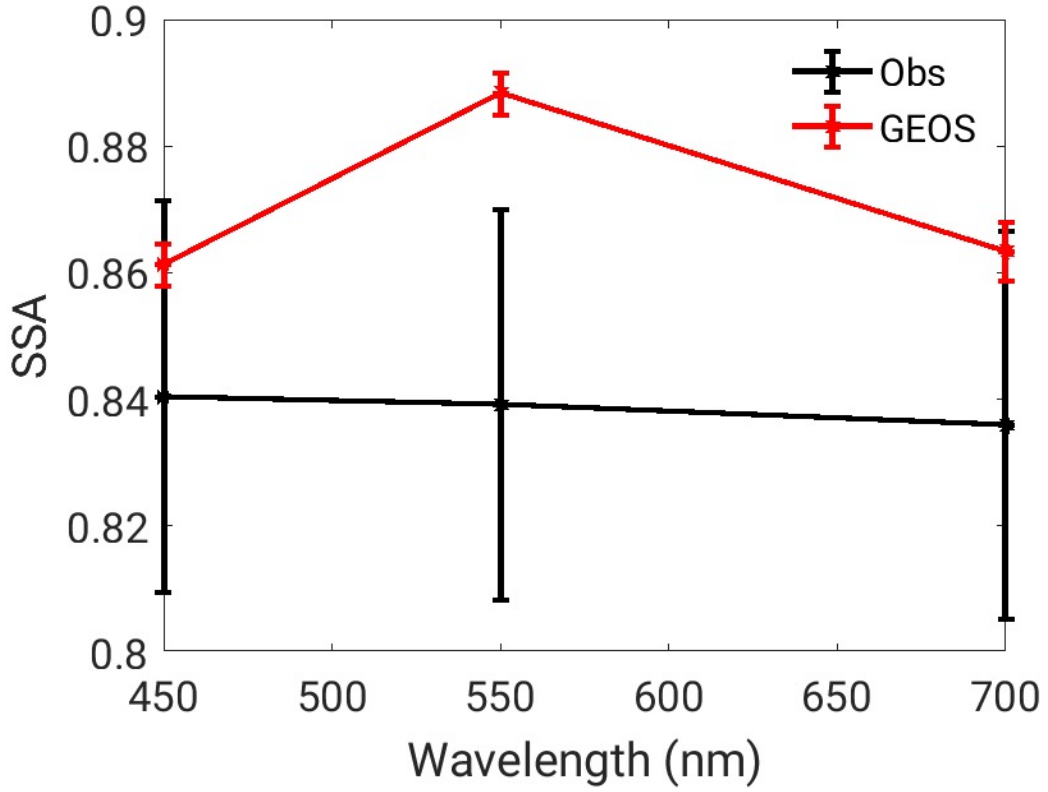
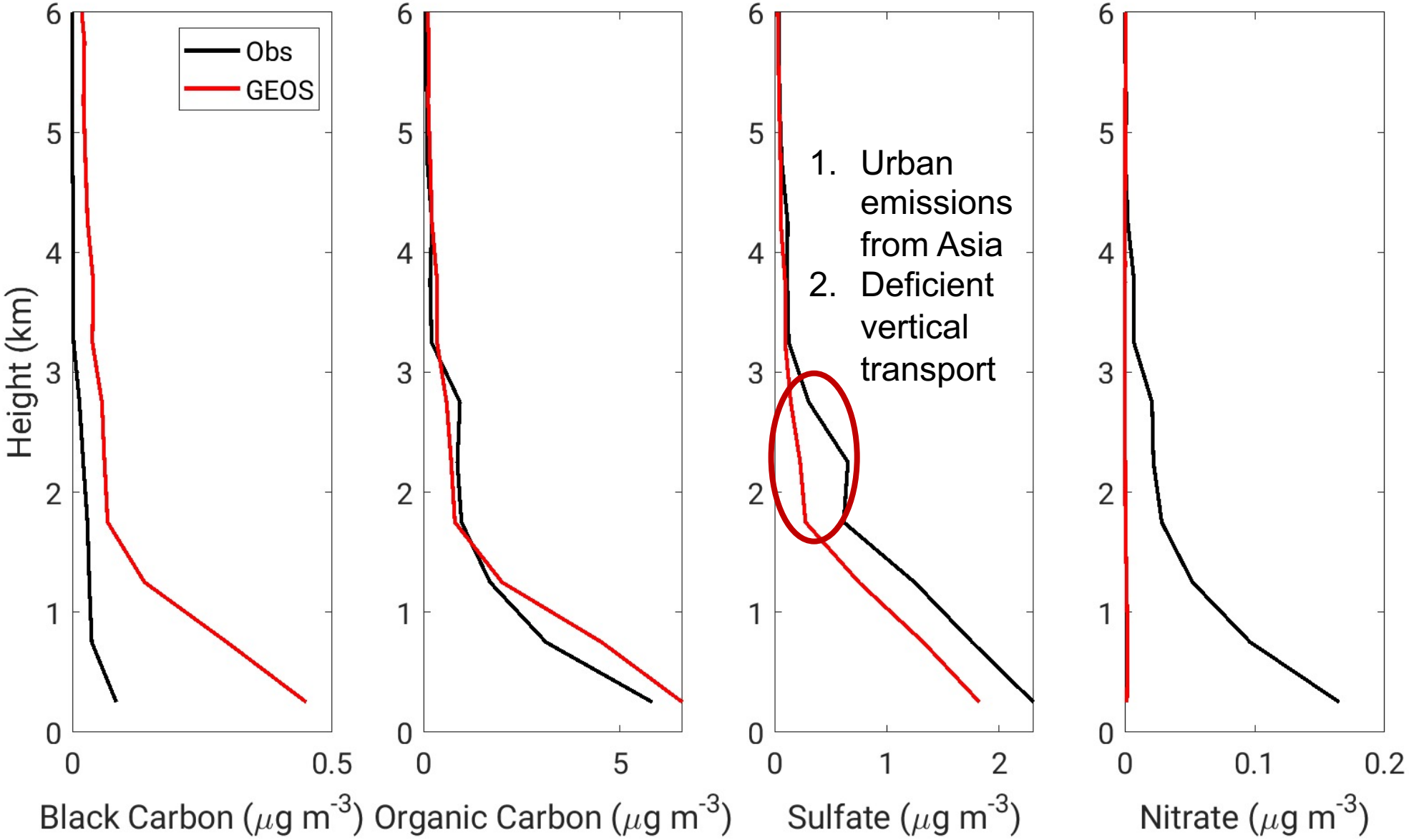
Extra Figures


Ambient SSA at 550 nm
GEOS
LARGE Obs
0.95
0.9
0.85
0.8
0.8
0.85
0.9
0.95
Ambient SSA at 550 nm
GEOS Aerosols, Observed RH
LARGE Obs
RH Bias (%)
15
10
5
0
-5
-10
-15


Scattering at 450 nm (km-1)
SSA at 450 nm
Scattering at 550 nm (km-1)
SSA at 550 nm
Scattering at 700 nm (km-1)
SSA at 700 nm
GEOS
LARGE Obs


Obs
GEOS
SSA
Wavelength (nm)

Aerosol Speciation in a Meteorological Replay



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- Latest emissions from CEDS
  - Accurate?
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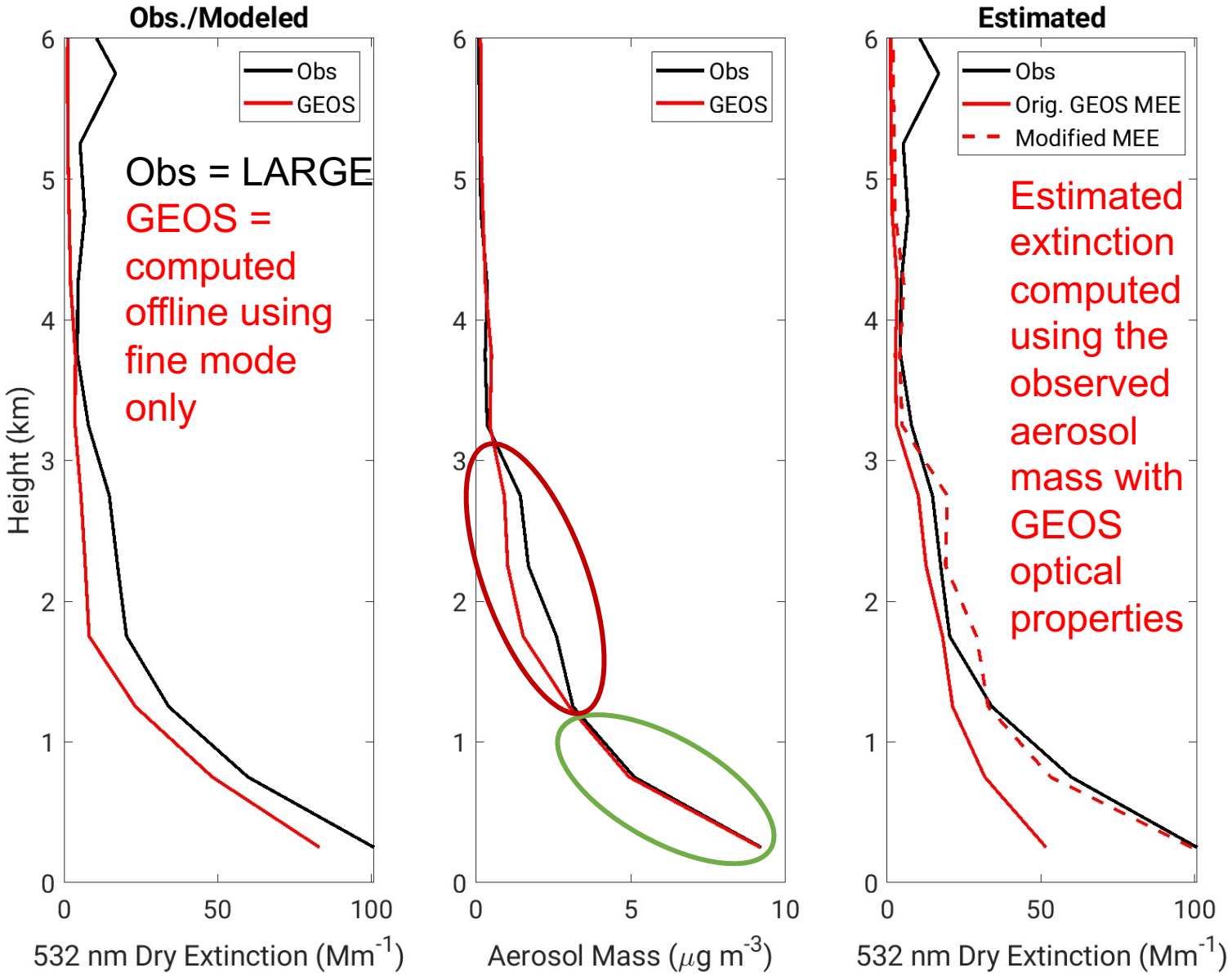
532 nm Dry Aerosol Extinction in a Meteorological Replay



- No assimilation of AOD
- Only flights with biomass burning aerosol
- Excellent agreement in BL aerosol mass, but underestimated extinction
- Not enough aerosol just above BL, coincides with bias in RH (presented last week)
- Indicative of insufficient aerosol emissions and vertical transport
- Estimated extinction is worse that modeled extinction -> speciation incorrect?
- Dashed line = what values do I need to used for the speciated MEE to match the observations?

	Org.	BC	SO4	NO3
Original MEE	4.07	9.29	7.06	7.94
Modified MEE	11.5	9.29	4.07	7.94